Requirements Document were used a source documents for the TSDIS information. The ECS Functional and Performance Requirements and the IRD were used as ECS source documents. Each of the interfaces between ECS and TSDIS were examined with respect to the length of time which data is archived for each interface and the detailed results are in the following exhibit. The IRD was the only document which specified which products were to be archived. However, several products were marked for archival but the length of the archival period was not specified.

Location: Products	**TSDIS System /Segment Design Specification**	**TSDIS Requirements Document, Rev. 3**	**IRD Between The ECS And TRMM Ground System**	**F&P Requirements Specification For The ECS**	**Δ ECS vs. TRMM**	**%Δ**
SDPF						
CERES Level 0 Datasets			5 Days			
CERES Raw Data			730 Days			
LIS Level 0 Datasets			5 Days			
LIS Data			730 Days			
ECS						
Definitive Orbit Data			---			
LaRC DAAC						
CERES Standard Products			---			
MSFC DAAC						
LIS Standard Products			---			
PR, TMI, GV Data			---			
GSFC DAAC						
VIRS Data			---			

Exhibit A-19 Archived Data Products

Exhibit A-17 SDPF Data Volumes

A.2.2.2 Data Rates

No data rates for ground system transmissions have been specified in the IRD or in any of the supporting documentation.

A.2.2.3 Frequency of Transmissions

The frequency of transmission of data between ECS and TSDIS were examined for consistency. The TSDIS System/ Segment Design Specification and the TSDIS Requirements Document were used a source documents for the TSDIS information. The ECS Functional and Performance Requirements and the IRD were used as ECS source documents. Each of the interfaces between ECS and TSDIS were examined with respect to the frequency which data is transmitted across the interface and the detailed results are in the following exhibit. The IRD was the only document which specified the frequency of transmissions of data. Several data types were mentioned in the IRD but no frequency of transmissions were stated.

Data flow: Product	**TSDIS System /Segment Design Specification**	**TSDIS Requirements Document, Rev. 3**	**IRD Between The ECS And TRMM Ground System**	**F&P Requirements Specification For The ECS**	**Δ ECS vs. TRMM**	**%Δ**
SDPF to LaRC DAAC						
CERES Level 0 Datasets			1 / Day			
CERES Quick-Look Datasets			3 / Day			
Notification of Availability						
SDPF to MSFC DAAC						
LIS Level 0 Datasets			1 / Day			
LIS Quick-Look Datasets			3 / Day			
Notification of Availability						
MSFC to TSDIS						
TRMM PR, TMI, GV, and SSM/I Ancillary Data			1 / Day			
GSFC to TSDIS						
TRMM VIRS, AVHRR, GPI, GPCP, NMC Ancillary Data			1 / Day			

Exhibit A-18 Frequency of Product Transmissions

A.2.2.4 Archived Products

The length of the archival periods for data between ECS and TSDIS were examined for consistency. The TSDIS System/ Segment Design Specification and the TSDIS

Exhibit A-15 LaRC DAAC Data Volumes

The volumes for each of the data types exchanged with the GSFC DAAC are listed in Exhibit A-16 below. Inconsistencies which were found here are considered minor.

	TSDIS System /Segment Design Specification	TSDIS Requirements Document, Rev. 3	IRD Between The ECS And TRMM Ground System	F&P Requirements Specification For The ECS	Δ ECS vs. TRMM	%Δ
TSDIS to GSFC						
Direct Processing						
VIRS Level 1A-3, Browse	1409 MB/day	1412 MB/day	1408.5 MB/day		3	0%
Reprocessing						
VIRS Level 1A-3, Browse	2817 MB/day		2800 MB/day		17	1%
GSFC to TSDIS						
Reprocessing						
VIRS Level 1B	1487 MB/day		1500 MB/day		13	1%

Exhibit A-16 GSFC DAAC Data Volumes

The volumes for each of the data types exchanged with the SDPF are listed in Exhibit A-17 below. A 50% difference was found between the IRD and the ECS F&PR for the CERES Level 0 data. A 29% difference in TMI Level 0 data was found between the IRD and the TSDIS Requirements Document Rev. 3.

	TSDIS System /Segment Design Specification	TSDIS Requirements Document, Rev. 3	IRD Between The ECS And TRMM Ground System	F&P Requirements Specification For The ECS	Δ ECS vs. TRMM	%Δ
SDPF to MSFC						
LIS Level 0			65 MB/day	65 MB/day	0	0%
SDPF to LaRC						
CERES Level 0			108 MB/day	216 MB/day	108	50%
SDPF to TSDIS	2435 MB/day					
VIRS Level 0	478 MB/day	495 MB/day	477.7 MB/day	*	17	3%
PR Level 0	967 MB/day	967 MB/day	967.3 MB/day	1760 MB/day*	0	0%
TMI Level 0	89 MB/day	63 MB/day	89.1 MB/day	*	26	29%
Definitive/Predictive Orbit	1 MB/day				0	0%
Scheduled Quick-look	300 MB/day					
On-demand Quick-look	500 MB/day					
Spacecraft Housekeeping Data	100 MB/day					

* Combined Volume

The volumes for each of the data types exchanged over the MSFC DAAC interface are listed in Exhibit A-14 below. Differences were found between the volumes from the ECS F&PR and the IRD and the IRD and the TSDIS documents for direct processing, and PR and TMI Level 1-3.

	TSDIS System /Segment Design Specification	**TSDIS Requirements Document, Rev. 3**	**IRD Between The ECS And TRMM Ground System**	**F&P Requirements Specification For The ECS**	**Δ ECS vs. TRMM**	**%Δ**
TSDIS to MSFC						
Direct Processing	12652 MB/day	13945 MB/day	12582.9 MB/day	15924 MB/day	3341	21%
GV Level 1-3	5938 MB/day	6296 MB/day	5924.5 MB/day		371	6%
PR Level 1-3	4364 MB/day	6389 MB/day	4325.2 MB/day		2064	32%
TMI Level 1-3	2350 MB/day	1260 MB/day	2333.2 MB/day		1090	46%
Reprocessing	25302 MB/day		26700 MB/day		1398	5%
GV Level 1-3	11875 MB/day					
PR Level 1-3	8728 MB/day					
TMI level 1-3	4699 MB/day					
MSFC to TSDIS						
Reprocessing	8020 MB/day		9400 MB/day		1380	15%
GV	1510 MB/day					
PR Level 1A	2291 MB/day					
TMI Level 2A	4219 MB/day					

Exhibit A-14 MSFC DAAC Data Volumes

The volumes for each of the data types exchanged with the LaRC DAAC are listed in Exhibit A-15 below. A 50% difference was found between the IRD and the F&PR for the CERES Level 0 data.

	TSDIS System /Segment Design Specification	**TSDIS Requirements Document, Rev. 3**	**IRD Between The ECS And TRMM Ground System**	**F&P Requirements Specification For The ECS**	**Δ ECS vs. TRMM**	**%Δ**
SDPF to LaRC						
CERES Level 0			108 MB/day	216 MB/day	108	50%

The volumes for each of the data types going into TSDIS are listed in Exhibit A-13 below. The differences between the volumes from the IRD and the TSDIS documents for TMI Level 0 could be due to the TSDIS document being issued in June versus July.

Incoming:	TSDIS System /Segment Design Specification	TSDIS Requirements Document, Rev. 3	IRD Between The ECS And TRMM Ground System	F&P Requirements Specification For The ECS	Δ ECS vs. TRMM	%Δ
SDPF to TSDIS	2435 MB/day					
Spacecraft Housekeeping Data	100 MB/day					
PR Level 0 Data	967 MB/day	967 MB/day	967.3 MB/day	*	0	0%
TMI Level 0	89 MB/day	63 MB/day	89.1 MB/day	1760 MB/day*	26	29%
VIRS Level 0	478 MB/day	495 MB/day	477.7 MB/day	*	0	0%
Definitive/Predictive Orbit Data	1 MB/day					
Scheduled Quick-look Data	300 MB/day					
On-demand Quick-look	500 MB/day					
Ground Validation to TSDIS	2266DD / 4427DP					
Kwajalein (Direct Data)	206 MB/day	620 MB/day				
Guam (Direct Data)	1030 MB/day	620 MB/day				
Hawaii (Direct Data)	1030 MB/day	620 MB/day				
Darwin (Direct Processing)	537 MB/day	551 MB/day				
Florida (Direct Processing)	1626 MB/day	1719 MB/day				
Texas (Direct Processing)	1397 MB/day	1101 MB/day				
Thailand (Direct Processing)	308 MB/day	895 MB/day				
Taiwan (Direct Processing)	308 MB/day	57 MB/day				
Israel (Direct Processing)	125 MB/day	57 MB/day				
Sao Paolo (Direct Processing)	125 MB/day	57 MB/day				
EOSDIS to TSDIS (Direct Processing)						
Non-TRMM Data (GPI, GPCP, NMC)	40 MB/day		38.3 MB/day		2	5%
EOSDIS to TSDIS (Reprocessing)						
Non-TRMM Data (GPI, GPCP, NMC)	80 MB/day					
VIRS Level 1B	1487 MB/day		1500 MB/day		13	1%
PR Level 1A	2291 MB/day		*			
TMI Level 2A	4219 MB/day		9400 MB/day*		10	0%
GV	1510 MB/day		*			
Combined Products	1390 MB/day		*			

* Combined Volume

Exhibit A-13 TSDIS Incoming Data Volumes

A.2.2.1 Data Volumes

The data volume between ECS and TSDIS were examined for consistency. The TSDIS System/ Segment Design Specification and the TSDIS Requirements Document were used a source documents for the TSDIS information. The ECS Functional and Performance Requirements and the IRD were used as ECS source documents. Each of the interfaces between ECS and TSDIS were examined with respect to their data volumes and the detailed results are in the following exhibits. Many inconsistencies with data volumes were found.

The volumes for each of the data types leaving the TSDIS are listed in Exhibit A-12 below. The differences between the volumes from the IRD and the TSDIS documents for PR and TMI Level 1-3 and combined products could be due to TSDIS Requirements Document Rev. 3 being issued in June versus July. A 7% difference was found for the TSDIS to EOSDIS direct processing.

Outgoing:	**TSDIS System /Segment Design Specification**	**TSDIS Requirements Document, Rev. 3**	**IRD Between The ECS And TRMM Ground System**	**F&P Requirements Specification For The ECS**	**Δ ECS vs. TRMM**	**%Δ**
TSDIS to EOSDIS (Direct Processing)	14767 MB/day	15704 MB/day	14766.7 MB/day	15924 MB/day	1157	7%
VIRS Level 1-3, Browse (to GSFC DAAC)	1409 MB/day	1412 MB/day	1408.5 MB/day		3	0%
PR Level 1-3, Browse (to MSFC DAAC)	4364 MB/day	6389 MB/day	4364.2 MB/day		2025	32%
TMI Level 1-3, Browse (to MSFC DAAC)	2350 MB/day	1260 MB/day	2349.6 MB/day		1090	46%
GV Level 1-3, Browse (to MSFC DAAC)	5938 MB/day	6296 MB/day	5937.7 MB/day		358	6%
Combined Products	707 MB/day	347 MB/day	706.7 MB/day		360	51%
TSDIS to EOSDIS (Reprocessing)	29534 MB/day					
VIRS Level 1-3, Browse (to GSFC DAAC)	2817 MB/day		2800 MB/day		17	1%
PR Level 1-3, Browse (to MSFC DAAC)	8728 MB/day		*			
TMI Level 1-3, Browse (to MSFC DAAC)	4699 MB/day		26700 MB/day*		10	0%
GV Level 1-3, Browse (to MSFC DAAC)	11875 MB/day		*			
Combined Products	1413 MB/day		*			

* Combined Volume

Exhibit A-12 TSDIS Outgoing Data Volumes

IRD Diagram	IRD Dataflow Chart	IRD Requirements	TSDIS Requirements
Level 1A Data	Archived Level 1A Data	Archived Level 1A Data	Archived Level 1A Data
Level 2 Data	Archived Level 2 Data	Archived Level 2 Data	Archived Level 2 Data
Level 3 Data	Archived Level 3 Data	Archived Level 3 Data	Archived Level 3 Data
Ancillary Data	Ancillary Data	AVHRR, GPI, GPCP, and NMC Ancillary Data	
	Metadata		
	Browse		
	Algorithms		
	Documentation		

Exhibit A-10   GSFC DAAC to TSDIS Data Types

A.2.1.5 SDPF to TSDIS

Exhibit A-11 lists the data types that were encountered for the SDPF to TSDIS interface (Dataflow 8). The IRD diagram [page 4-1] and the IRD data flow chart [page 3-3] are not consistent for the SDPF to TSDIS interface. The diagram lists science and housekeeping data and the data flow chart lists only level 0 data. The TSDIS requirements document additionally lists platform ancillary data, level 0 data, and predictive orbit data. These problems should be addressed at or before the ICD level when the TSDIS to DAAC interfaces are further defined.

IRD Diagram	IRD Dataflow Chart	IRD Requirements	TSDIS Requirements
Science Data			
Housekeeping Data			Platform Ancillary Data
Quick-look Data	Quick-look Data		Quick-look Data
Definitive Orbit Data	Definitive Orbit Data		Definitive Orbit Data
			Predictive Orbit Data
	Level 0 Data		

Exhibit A-11   SDPF to TSDIS Data Types

A.2.2 Consistency Analysis Results

Exhibits A-12 through A-19 contain the detailed results of the interface consistency analysis. Two metrics were applied to each of these figures, the first to determine the greatest difference between values, and the second to determine the percentage difference. The Δ represents the |greatest ECS volume - smallest TRMM volume|, or the greatest difference. and %Δ represents Δ / the greatest ECS volume, or the percentage difference.

sent to the TRMM Science Team after a TRMM product has been reprocessed, and thereby, the old data becomes eligible for deletion. This data flow is not present in the data flow chart or the IRD diagram. The IRD requirements also state that products status information for TRMM products will be available. This requirement for products status information is ambiguous since it does not state whether this information will be available through EOSDIS or through TRMM. If the information is needed through TRMM, a data flow needs to be established and added to the IRD.

IRD Diagram	IRD Dataflow Chart	IRD Requirements	TSDIS Requirements
Correlative Data	Correlative Data		Non-TRMM Data
Ancillary Data	Ancillary Non-TRMM Data		Ancillary Data

Exhibit A-8 ECS to TSDIS Data Types

A.2.1.4 DAACs to TSDIS

One minor problem was discovered for the DAAC to TSDIS interface. Exhibit A-9 lists the data types that were encountered for the MSFC DAAC to TSDIS interface (Dataflow 6) and Exhibit A-10 lists the data types that were encountered for the GSFC DAAC to TSDIS interface (Dataflow 7). The IRD data flow chart [page 3-2] lists metadata, browse, algorithms, and documentation. This data has not been included in the other IRD diagrams, nor the IRD or TSDIS requirements. These problems should be addressed at the ICD level when the DAAC to TSDIS interfaces are further defined.

IRD Diagram	IRD Dataflow Chart	IRD Requirements	TSDIS Requirements
Level 1A Data	Archived Level 1A Data	Archived Level 1A Data	Archived Level 1A Data
Level 2 Data	Archived Level 2 Data	Archived Level 2 Data	Archived Level 2 Data
Level 3 Data	Archived Level 3 Data	Archived Level 3 Data	Archived Level 3 Data
Ancillary Data	Ancillary Data	SSM/I Ancillary Data	
	Metadata		
	Browse		
	Algorithms		
	Documentation		
	Ground Validation Data	Archived Ground Validation Data	Archived Ground Validation Data

Exhibit A-9 MSFC DAAC to TSDIS Data Types

	Chart		Requirements
Level 1A Data	Level 1A Data	Level 1A Data	Level 1A Data
Level 1B Data	Level 1B Data	Level 1B Data	Level 1B Data
Level 2 Data	Level 2 Data	Level 2 Data	Level 2 Data
Level 3 Data	Level 3 Data	Level 3 Data	Level 3 Data
Metadata	Metadata	Metadata	Metadata
Browse	Browse	Browse (PR & TMI)	Browse
Algorithms	Algorithms	Algorithms	Software
Documentation	Documentation	Documentation	Documentation
	Ground Validation Data	Ground Validation Data	Level 1B Ground Validation Data
Schedule	Availability Schedule	Electronic Schedule	
	Status	Status Information	

Exhibit A-6 TSDIS to MSFC DAAC Data Types

IRD Diagram	IRD Dataflow Chart	IRD Requirements	TSDIS Requirements
Level 1A Data	Level 1A Data	Level 1A Data	Level 1A Data
Level 1B Data	Level 1B Data	Level 1B Data	Level 1B Data
Level 2 Data	Level 2 Data	Level 2 Data	Level 2 Data
Level 3 Data	Level 3 Data	Level 3 Data	Level 3 Data
Metadata	Metadata	Metadata	Metadata
Browse	Browse	Browse	Browse
Algorithms	Algorithms	Algorithms	Software
Documentation	Documentation	Documentation	Documentation
Schedule	Availability Schedule	Electronic Schedule	
	Status	Status Information	

Exhibit A-7 TSDIS to GSFC DAAC Data Types

A.2.1.3 ECS to TSDIS

Three problems were found for the interface from ECS to TSDIS (Dataflow 5). Exhibit A-8 lists the data types that were encountered for the ECS to TSDIS interface. The first of these problems was minor. The requirements in Section 5.5 of the IRD do not list correlative and ancillary non-TRMM data. The requirements in Section 5.5 are information management requirements. The ancillary data will be transferred to TSDIS from the appropriate DAACs. The requirements for ancillary data are correctly listed in the IRD in sections 5.3 and 5.4. No requirements are listed in the IRD for correlative data. This issue is most likely caused by different definition of terms. The terms "ancillary data", "correlative data", and "Non-TRMM data" have all been used within both ECS and TRMM documents. The ECS F&PR Appendix A provides a definition for correlative data. Both Ancillary and Non-TRMM data need to be defined if they are different. An agreed upon definition of terms would probably solve this discrepancy.

The second and third problems with the ECS to TSDIS interface were more significant and dealt with user notifications. The IRD requirements state that a notification should be being considered. Currently there is a glossary of terms listed in Appendix A of the ECS F&PR, this glossary should be expanded and adhered to by all parties interfacing with ECS.

A.2.1.1 SDPF to DAACs

One minor problem was encountered with the SDPF to DAAC interfaces. Exhibit A-4 lists the data types that were encountered for the SDPF to MSFC DAAC interface (Dataflow 1) and Exhibit A-5 lists the data types that were encountered for the SDPF to LaRC DAAC interface (Dataflow 2). The IRD requirements list availability information that is sent to the DAACs from the SDPF. This information is not contained in any of the data flow diagrams or charts. This problem should be addressed at the ICD level when the SDPF to DAAC interface is further defined.

IRD Diagram	**IRD Dataflow Chart**	**IRD Requirements**	**TSDIS Requirements**
LIS Level 0 Data	LIS Level 0 Data	LIS Level 0 Data	NA
Quick-look Data	Quick-look Data	Quick-look Data	NA
Definitive Orbit Data	Definitive Orbit Data	Definitive Orbit Data	NA
Predictive Orbit Data	Predictive Orbit Data	Predictive Orbit Data	NA
		Availability Data	NA

Exhibit A-4 SDPF to MSFC DAAC Data Types

IRD Diagram	**IRD Dataflow Chart**	**IRD Requirements**	**TSDIS Requirements**
CERES Level 0 Data	CERES Level 0 Data	CERES Level 0 Data	NA
Quick-look Data	Quick-look Data	Quick-look Data	NA
Definitive Orbit Data	Definitive Orbit Data	Definitive Orbit Data	NA
Predictive Orbit Data	Predictive Orbit Data	Predictive Orbit Data	NA
		Availability Data	NA

Exhibit A-5 SDPF to LaRC DAAC Data Types

A.2.1.2 TSDIS to DAACs

The analysis of the TSDIS to DAAC interfaces revealed two minor problems. Exhibit A-6 lists the data types that were encountered for the TSDIS to MSFC DAAC interface (Dataflow 3) and Exhibit A-7 lists the data types that were encountered for the TSDIS to GSFC DAAC interface (Dataflow 4). The diagram in the IRD [page 4-1] does not list Ground Validation (GV) data. The IRD requirements and IRD dataflow chart list an additional data type for product status, which does not appear on the IRD diagram not in the TSDIS requirements. These problems should be addressed at the ICD level when the TSDIS to DAAC interfaces are further defined.

IRD Diagram	**IRD Dataflow**	**IRD Requirements**	**TSDIS**

Data accountability is extremely important in any large distributed system. A consistent, complete set of requirements concerning accountability in the ECS<->TRMM IRD does not currently exist. The lack of these requirements may cause the selection of an accountability scheme that is inappropriate, or possibly no accountability scheme to be selected at all. In any distributed system it can be extremely difficult to determine the source of a fault without an accountability scheme. In this specific instance there are two different data paths that need to be considered: SDPF to ECS and SDPF to TSDIS. There are three different organizations involved in these data paths. The placement for the accountability needs to be allocated to both sides of the interface. If additional accountability is put on ECS, then it also needs to be put on TSDIS. It is recommended that a complete set of accountability requirements be added to this IRD.

A.1.2.3 Security

There are no references to security standards in the ECS<->TRMM IRD. Protections that are available or necessary on the actual data or the directories which contain the data need to be stated clearly in the requirements. The requirements for security on archived data, and for access to archived data should be provided in the ECS F&PR. If additional requirements for security are needed beyond what is provided by the communication network, those requirements should be placed in the IRD. This interface should be following the standards set forth in the NASA Automated Information Security Handbook [Ref. 7].

A.2 INTERFACE IMPLEMENTATION

A.2.1 Data Content, Completeness, and Expression

The majority of the inconsistencies that were found in this phase of the analysis were internal to the IRD. Many inconsistencies were found between the IRD dataflow chart, the IRD diagrams and the IRD requirements. However, several inconsistencies were found between the IRD and the TSDIS requirements.

Several problems were encountered during this analysis which dealt with inconsistent use of terminology for data items. In the case of the TRMM IRD, inconsistencies were found within the IRD in the identification and naming of data items flowing across interfaces. The first example of these inconsistencies is the use of “ancillary and correlative data” versus the term “non TRMM data” in the ECS to TSDIS dataflow. A second example of this problem is the use of the term “housekeeping data” versus the term “Platform ancillary data” in the SDPF to TSDIS dataflow. The specific inconsistencies were not in themselves severe for these interfaces, however, spot checks across supporting documents showed inconsistencies in data definitions. Inconsistent data definitions by TSDIS, SDPF, and ECS, if left uncorrected, could lead to confusion by the different developers over the nature of the data flowing across the interface. It is thus recommended that the ESDIS project establish and baseline a detailed set of data definition, element names if this is not

Several requirements in the IRD make the following statement, “The interfaces between TRMM and ECS shall make appropriate use of standards for data structures and data transport as defined for use within the publications of CCSDS and ISO/OSI, and shall use commercial off-the-shelf (COTS) hardware and software products as appropriate.” This requirement is ambiguous. It is difficult to understand how such a wide body of hardware, software and standards can be applied “appropriately” in the development of this particular interface. The standards that need to be applied, should be specifically stated. The wording “as appropriate” should be replaced by specific information that can help direct the development effort.

A reference is made in the requirements to standard information management functions (TRMM 5060, 5090). Again these standard functions need to be officially defined and documented. A brief description of the functions required should be provided in the requirements, or an appropriate and officially sanctioned standards document should be referenced if one exists.

A.1.2.2 Data Transport

The selection of interface protocols is an important design issue and the requirements should be clearly defined so as to facilitate this process. Data quality and performance requirements at each level in the ISO model stack should provide information to aid the designer in protocol selection.

In the case of the ECS<->TRMM IRD, the requirements allow a wide range of choices at the ICD level. For example, references are made to error checking and retransmission of data without specifying whether these are automatic electronic processes, or manual human initiated processes. The requirements do not distinguish between automatic and manual processes, or between electronic and manual media. Quantitative quality specifications (e.g., complete, error free file transfers) are not provided. A wide choice of specific protocols is thus allowed at all protocol levels (e.g., application, network, etc.).

The GSAD shows the interfaces between TSDIS and the ECS DAACs using the NASCOM networks. If the GSAD is accurate, the IRD should state that the interfaces will be using the NASCOM networks. Otherwise, the IRD should provide specific requirements to guide the developers in their choice of available networks.

The IRD does not provide performance requirements on which the selection of specific data transport protocols could be based. The lack of performance requirements therefore allows for a wide range of candidate protocols from which to select at the ICD level. The concern becomes selecting protocols that can meet the performance and data quality requirements of the interface. The risk of selecting unsuitable protocols can be significantly reduced by carefully specifying the performance and quality requirements that must be met by the chosen protocols. During this selection process it is equally important to select stable, modern protocols capable of supporting the future demands of the system.

Exhibit A-2 Incomplete Requirements

A general observation made during the integrity analysis was that the IRD fails to place any performance requirements on the interface. These types of requirements generally establish any system performance constraints that may exist and help steer the protocol selection process. It is recommended that if basic system performance parameters are know they should be explicitly stated in the IRD.

A.1.1.3 Inconsistent Requirements

Inconsistent requirements either lack in agreement with the overall mission and/or desired functionality, or this agreement is questionable. Exhibit A-3 will present the most significant of these problems. The specific requirements, a description of the problem, an impact statement, and a recommendation as to how the requirement could be improved is provided.

Requirements	Problem Description	Impact Statement	Recommendation
TRMM 4120	The IRD specifies that the TSDIS and ECS are to provide an interface to the GSFC local area network. There is, however, no corresponding requirement placed on the MSFC <> ECS interface. This interface is not shown on the data flow diagram nor listed under institutional support systems in the IRD.	It is not clear why the ECS must support an interface with the GSFC LAN. There is no requirement for the ECS to interface with the MSFC LAN. This interface is not described in sufficient detail to understand its function.	Describe the function of this interface and include it in the TRMM<->ECS context diagrams and data flows.

Exhibit A-3 Inconsistent Requirements

A.1.2 Adherence to Standards Analysis Results

A.1.2.1 Data Formats and Standards

A number of standards and formats are referenced within the IRD without referencing the originating document or specification. Requirements TRMM 1180 and TRMM 2170 discuss "SDPF-defined formats" that are to be used for Level 0 and quick-look data from CERES and LIS, TRMM 3130 and TRMM 4130 include "ESDIS-defined standards" for all data transferred between TSDIS and the ECS GSFC DAAC and requirement TRMM 5010 refers to "ECS format" in describing TRMM metadata, browse and standard products. Pointers to applicable documents would provide the necessary linkages.

A.1.1.2 Incomplete Requirements

Incomplete requirements are those requirements whose overall goal or function is incompletely specified or missing. Exhibit A-2 presents the four most significant of these problems. The specific requirements, a description of the problem, an impact statement, and a recommendation as to how the requirement could be improved is provided.

Requirements	Problem Description	Impact Statement	Recommendation
TRMM 1050, TRMM 2050	The IRD places a requirement on SDPF to notify the MSFC and LaRC DAACs upon availability of LIS and CERES Level 0 or quick-look data, respectively. The requirements do not specify the method of interaction between the two elements. (e.g., human-to-human, computer-to-computer)	It is important to identify the method of interaction as early as possible in the specification of this interface. Defining the method of interaction early on helps prevent non-uniform implementations of element-to-element interfaces.	If the method of interaction is know it should be stated in the IRD.
TRMM 1060, TRMM 2060	The IRD fails to specify the capabilities that are to be supported by the file transfer protocols selected to transport data products across the TRMM<->ECS interfaces.	The specification of these capabilities is crucial to understanding the performance characteristics and error detection and correction capabilities that need to be supported by the selected protocols.	Identify the capabilities that must be supported by the protocol selected - this could then be used to guide the protocol selection process.
TRMM 1160, TRMM 2160	The IRD states that CERES and LIS special quick-look data collection and processing be scheduled with SDPF. This does not sufficiently describe the intricacies of the scheduling process. A related requirement (TRMM 1170) stipulates that data collected and processed for CERES solar calibration must also be scheduled. The comments provided apply to this requirement as well.	The ICD must minimally identify: who approves schedule requests, who generates schedules, when schedule requests must be submitted, how schedule requests are submitted, how requests are prioritized and how scheduling is accomplished (manually or electronically). Without this additional information it would difficult (if not impossible) to ascertain that the requisite scheduling functions are present and operating as intended.	Identify the requisite scheduling functions that must be supported for quick-look data collection (CERES and LIS) and for CERES solar calibration in the IRD. If know, identify how scheduling is performed. (If this is an electronic process, a new data item would need to be introduced into the data flow)
TRMM 1230, TRMM 1240, TRMM 2220, TRMM 2230	The IRD places requirements on the CERES and LIS instrument and science teams to define the data and algorithms needed for their processing. The IRD fails to identify the systems that must interface to accomplish the transfer of data definitions and algorithms.	The instrument and science teams are responsible for defining the data, processing algorithms and the operations concept needed for their processing. This requirement is not a function or process directly associated with the TRMM<->ECS interface.	Remove this requirement from this IRD and place it in the SCF<->ECS IRD.

	the distinction is between "special" quick-look and standard quick-look data.		
TRMM 1200, TRMM 1210, TRMM 1220, TRMM 2190, TRMM 2200, TRMM 2210	The requirements do not define the process by which the MSFC and LaRC DAACs are informed of the availability of predictive and definitive orbit data. The requirements stipulate that the definitive orbit data must be archived by the DAACs, but they do not establish a minimum time period for the maintenance of this data.	The developers will require additional detail on archive requirements placed on the DAAC and the method of interaction between the DAAC and SDPF. This information will help guide the design process and lead to an implementation that better represents the intended functionality.	The IRD should specify the frequency of receipt of predictive and definitive orbit data and define the process by which the DAAC is informed of the availability of this data. Suggest using the term "retain" in place of archive if this only short term storage.
TRMM 1270, TRMM 2260	The IRD stipulates in the requirements, that the ECS elements must support TRMM end-to-end testing. The word "support" does not sufficiently describe the functionality that must be provided by the ECS to satisfy the TRMM end-to-end test effort.	The use of terms such as "support" allow a wide range of interpretations. A safer approach is to specify in greater detail the functions to be supported as early as possible in the design process.	Within the IRD, identify the data flows and the operational requirements of each ECS interface that will be needed during testing.
TRMM 1290, TRMM 2280, TRMM 3140, TRMM 4140	The IRD states that the ECS and TRMM GS interface must make appropriate use of standards. The term "appropriate" leaves this requirement wide open for interpretation. The only limiting factor for data structure and data transport are the CCSDS and ISO/OSI publications. Citing these standards in their entirety does not demonstrate how these standards are to be applied in the specification of ECS<-> TRMM data transport protocols or in the design of ECS<->TRMM data structures. Similarly, the "appropriate" use of COTS hardware and software is a highly subjective evaluation.	Adherence to accepted standards is a reasonable goal, but more detail are necessary to determine the specific standards that are to be used in designing the ECS<->TRMM interfaces. The current requirements provide little direction to the developers related to the selection of standards, data structures, hardware and software.	Define the term "appropriate". Specify the applicable CCSDS data structures and ISO/OSI standards that will be adhered to by the TRMM<->ECS interface definition. Also consider changing "ECS" to "ECS LaRC DAAC" to distinguish requirements TRMM 1290, TRMM 2280, TRMM 3140 and TRMM 4140 from each other. The ICD(s) will be monitored to determine if these standards have been clearly specified and subsequently met.

Exhibit A-1 Ambiguous Requirements

APPENDIX A DETAILED ANALYSIS RESULTS FOR TRMM

A.1 INTERFACE REQUIREMENTS

A.1.1 Technical Integrity Analysis Results

A.1.1.1 Ambiguous Requirements

Several problems have been identified dealing with ambiguous requirements. Ambiguous requirements are those requirements that are unclear and therefore allow for multiple interpretations. Exhibit A-1 will present the most significant of these problems. The specific requirements, a description of the problem, an impact statement, and a recommendation as to how the requirement could be improved is provided.

Requirements	Problem Description	Impact Statement	Recommendation
TRMM 1070, TRMM 2070	The MSFC and LaRC DAACs are to ensure that incoming CERES and LIS data has been received and validated. The requirement does not state whether receipt verification is a manual or electronic process.	It is advantageous to define the method of interaction early on to promote a consistent design approach. Unclear terminology requires interpretation during low level design and will often result in non-uniform implementations of similar functions.	Distinguish electronic processes from manual processes in the IRD. If the validation process goes beyond simple data accounting, the responsibilities and processes should be described in more detail.
TRMM 1090, TRMM 2090	Data sets that fail validation can be regenerated by SDPF if necessary, and the need for regeneration is jointly assessed by the SDPF and the DAAC. The requirement fails to identify the method of interaction (human or electronic) that the SDPF and the DAAC will utilize while assessing the need for regeneration. Responsibility for this interaction is not clearly placed on a specific entity.	These requirements do not contain the details necessary to properly guide the developers in the implementation of this function. Also, by not clearly identifying the organization responsible for maintaining data quality the potential for dispute arises.	The IRD should identify the method of interaction (human or electronic) that the SDPF and the DAAC will utilize while assessing the need for regeneration and additionally assign one of these organizations the responsibility for data quality assurance.
TRMM 1130, TRMM 2130	Requirements state that the MSFC and LaRC DAACs will receive “occasional quick-look data sets”. The term “occasional” is vague and does not quantify the anticipated frequency of receipt of these products. In addition, it is not clear what	The terms “occasional” and “special” do not convey the information necessary for the developers to understand the frequency or scope of these requirements.	The IRD should distinguish between special and standard quick-look data and quantify the term “occasional”

correct, it is recommended that the ECS F&PR be updated to correct these inconsistencies.

5.3.3 Technical Integrity

Problems were encountered with the technical integrity of the requirements for each interface described in the IRD. These problems were normally minor, however, a few significant issues were encountered. The majority of the minor problems dealt with internal document inconsistencies while the others dealt with inconsistencies between the ECS<->TRMM IRD and the TSDIS requirements document. Specific results were presented in Section 4.2.2. Appendix A, Sections A.1.1.1 through A.1.1.4, present each of these problems, describing the specific requirements, a description of the problem with the requirement, and a recommendation as to how the requirement could be improved. One of the significant problems dealt with the ECS to TSDIS interface in section 5.5 of the ECS<->TRMM IRD. This section dealt with information management interface F&PR. No distinction between an interface F&PR and an information management interface F&PR was presented.

5.4 SPECIFIC RECOMMENDATIONS

The following is a summary of the specific recommendations which flowed out of the TRMM <-> ECS IRD analysis.

- Develop a data dictionary,
- Develop specific performance requirements,
- Clarify and correct technical integrity issues,
- Update the ECS Functional and Performance Requirements to be consistent with the IRD,
- Clarify the difference between information management interface Functional and Performance Requirements and interface Functional and Performance Requirements.

5.3 SPECIFIC ANALYSIS FINDINGS

The following sections describe the specific findings that were encountered during the technical analysis of the ECS<->TRMM IRD. These findings were a direct result of our analysis. Associated with each of these findings is a specific recommendation. This recommendation can be found in Section 5.4.

5.3.1 Data Dictionary

An inconsistency was encountered during this analysis which dealt with inconsistent use of terminology for data items. A Data Dictionary should be created if one does not exist. This Data Dictionary should be provided to all contractors. Currently there is a glossary of terms listed in Appendix A of the ECS F&PR, this glossary should be expanded and adhered to by all parties interfacing with ECS. In the case of the TRMM IRD, inconsistencies were found within the IRD in the identification and naming of data items flowing across interfaces. One example of these inconsistencies is the use of "ancillary and correlative data" versus the term "non TRMM data". The specific inconsistencies were not in themselves severe for this interface, however, spot checks across supporting documents showed inconsistencies in data definitions. Inconsistent data definitions by TSDIS vs. ECS, if left uncorrected, could lead to confusion by the different developers over the nature of the data flowing across the interface. For example, there could be a 80% overlap but not a 100% overlap. This problem might not be discovered until integration testing. It is thus recommended that the ESDIS project establish and baseline a detailed set of data definition, element names if this is not being considered. All interface documentation (IRDs and ICDs) should be required to use these baselined definitions. Such project documents as the Ground System Architecture Diagram (GSAD) and Architecture Description Document (ADD) could, if updated, serve this purpose. Additionally, the specific requirements in the ECS F&PR need to be updated to be consistent with the new architecture for ECS.

5.3.2 Performance Requirements

The analysis of interface implementation identified a lack of performance requirements. This lack of performance requirements could lead to potential performance problems and integration problems. Requirements should be specified in terms of Mean Time Between Failures (MTBF), data rates supported, frequency of transmissions, and number of links needed. Some level of performance requirements should be added to the IRD.

Instances were found in the IRD, where the IRD and external documents were consistent, but both the IRD and the external documents were inconsistent with the ECS F&PR. A specific example of this was encountered with the data volumes. In this instance, the IRD and the TSDIS documents were consistent, but both documents were inconsistent with the ECS F&PR. The impact of this inconsistency is that system testing could pass and the key interface testing could fail, or vice versa. Assuming the interface documentation is

It would be helpful if the GSAD and ADD were baselined and the diagrams in the IRDs and ICDs utilized elements extracted from the GSAD and/or ADD. These diagrams provide consistent views of the ground system. The use of the GSAD and ADD as a basis for subsequent diagrams will facilitate the ingestion of information and subsequent analysis.

5.2.2 Standardize IRD and ICD Formats

Several IRD have been examined this far, and each has been in a different format. The ECS<->TRMM IRD used numbered references to data flows in the diagrams. This numbering was extremely helpful and we recommend the use of this practice for subsequent IRDs and ICDs. The ECS<->TRMM IRD also provided a table which included descriptions of interface functions, data types, interface development status, and ICD responsibility. The data flows were then cross referenced to the table. We recommend the use of a consistent format for all IRDs and ICDs. If all of the IRDs and ICDs use a specified format, document review will be considerably more efficient.

5.2.3 IRD and ICD Schedule

The baselined TRMM ICDs will be delivered only six months prior to the IR-1 ECS delivery. This schedule is very tight and could cause significant development problems if the schedule fluctuates. There is a six month period between the Draft ICD and the Baselined ICD. It is assumed that the development process will be pretty far along before the ICD will be baselined. The risk increases with the number of changes between the draft ICD and the baselined ICD. It would be more beneficial if the time period between the Draft and the baselined versions could be shortened and the length of time for interface development be increased.

5.2.4 Review and Reporting Approach

Based on the pilot analysis it was decided to shift towards doing interface analysis and reporting based on ECS releases rather than on individual IRDs. This level of reporting seems to provide a more effective and efficient approach, since it reduces any overlaps in support and project capabilities. This level of reporting also provides a forum to present any overall system level concerns which may arise from the system level analysis. With this approach, analysis and reporting will be performed on each of the key interfaces contained in each ECS release, as well as the overall system. The main body of the report will contain the overall system level concerns, and separate appendices will contain the interface specific concerns.

5. FINDINGS AND RECOMMENDATIONS

This section of the document presents the findings from the TRMM <-> ECS IRD analysis. Section 5.1 presents issues which may require further analysis. Section 5.2 presents general findings which were encountered during the analysis, but which were not a direct result of the analysis. Section 5.3 presents specific findings which were a result of the analysis. Section 5.4 summarizes the specific recommendations for the TRMM <-> ECS IRD.

5.1 AREAS REQUIRING FURTHER ANALYSIS

Further analysis is recommend for the length of archiving periods for data and the specific data types which are to be archived. The appropriateness of the use of the term "archive" needs to be examined. The term is used in places where it would seem the term "retention" would be more appropriate. Several data types are specific as to where they should be archived and for what length of time they should be archived. Other data types merely state that they should be archived, without stating a time period for the archival. If the intent is to archive data types for a predetermined length of time (i.e. Life of the Mission plus 5 years), then this should be stated in the introductory section of the IRD.

The data types listed for SDPF-to-DAAC data flows in the ECS Operations Concept do not contain the TRMM quick-look data listed in the ECS<->TRMM IRD. The IRD data flows show quick-look data across the SDPF-to-MSFC DAAC and the SDPF-to-LaRC DAAC interfaces. Further analysis is necessary to determine the reasons for these apparent inconsistencies.

5.2 GENERAL FINDINGS AND OBSERVATIONS

The following sections describe the general findings that were encountered during the technical analysis of the ECS<->TRMM IRD. These findings were not a direct result of our analysis but are included here as additional information.

5.2.1 Document Baselining

Several versions of the ECS <->TRMM IRD have been published, each containing different requirements. Analysis and review of the IRD can proceed with an unbaselined document, however, interface analysis and requirements analysis should be performed on a baselined version. The IRDs also need to be baselined expeditiously to provide a stable document, thus allowing the developers sufficient time to develop the subsequent ICDs. The IV&V team needs to become more integrated with the GSFC review process by being added to distribution lists and by receiving schedule updates. The team needs to be informed when new versions of documents are released and when comments for those documents are due to the authors. Working level points of contacts should also be established to ensure timely transmittal of significant issues.

Science Team after a TRMM product has been reprocessed, and thereby, the old data becomes eligible for deletion. This data flow is not present in the data flow chart or the IRD diagram. The IRD requirements also state that products status information for TRMM products will be available. This requirement for products status information is ambiguous since it does not state whether this information will be made available through EOSDIS or through TRMM. If the information is needed through TRMM, a data flow needs to be established and added to the IRD. Without these changes the interface may not support the needed data items.

4.3.3 Consistency Analysis

For the consistency analysis the IRD was compared to supporting documentation to evaluate its consistency. The following parameters were used in this evaluation: volume of data, rate of transmission of data, frequency of transmissions, and length of archiving of data. A brief summary of the problems encountered is provided below. Detailed results can be found in Appendix A.2.2.

Problems were encountered during this analysis which relate to the data volumes, data rates, frequency of transmissions, and length of archival periods. No data rates for ground system transmissions have been specified in the IRD or in any of the supporting documentation. In general, the IRD failed to include interface performance requirements such as BERs and data rates. The IRD was the only document that specified frequency of transmissions and length of archival periods. Additionally, several data types are listed as being archived at ECS but the length of the archival period is not specified.

4.4 INTERFACE DEVELOPMENT STATUS

According to the ESDIS Integration and Test IRD/ICD Tracking Matrix Rev. 6, dated October 26, 1994 schedule, the baselined TRMM ICDs will be delivered only six months prior to the IR-1 ECS delivery. This schedule is very tight and could cause significant development problems if the schedule changes. There is a six month period between the Draft ICD and the Baselined ICD. We recommend that the time period between the Draft and the baselined versions be shortened and the length of time for interface development be increased.

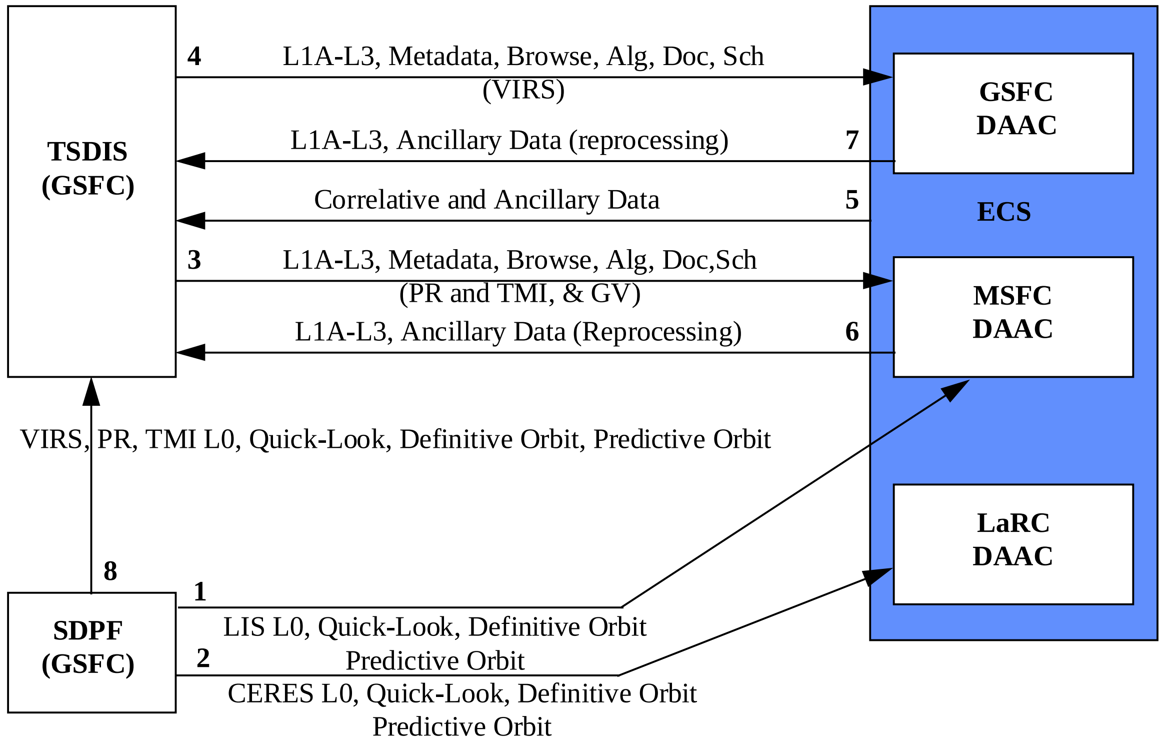

Exhibit 4-2 ECS<->TRMM Interface Structure

For each element on the block diagram, an input/output table was completed that contained information about the interface, the interface functions, and the data being passed. The input/output tables were then evaluated to verify the completeness and data content of the interface. For TRMM this was done manually and recorded using Excel spreadsheets. The tables containing this information can be found in Appendix A.

4.3.2 Data Content, Completeness, and Expression

Data Content problems were encountered with each interface described in the IRD, these problems were normally minor, however, a few significant issues were encountered. The majority of the minor problems dealt with internal document inconsistencies while the others dealt with inconsistencies between the ECS<->TRMM IRD and the TSDIS requirements document. One of the significant problems dealt with the ECS to TSDIS interface in section 5.5 of the ECS<->TRMM IRD. This section dealt with information management interface F&PR. No distinction between an interface F&PR and an information management interface F&PR was presented. Further details about this problem can be found in section 4.3.2.3. Detailed results for each of the interfaces presented in the IRD and any problems encountered during the analysis can be found in Appendix A.2.1.

Problems were encountered with the ECS to TSDIS interface that dealt with user notifications. The IRD requirements state that a notification should be sent to the TRMM

4.2.3 Traceability

The HAIS ECS<->TRMM RTM database was not available for use in this pilot analysis. Requirements traceability analysis will be performed at a later date using the RTM tool, and both parent-child and peer-to-peer traceability will be evaluated.

4.2.4 Adherence to Standards

Throughout the ECS<->TRMM IRD numerous references are made to standards that have not been defined. If standards are used, the standards need to be approved by all parties having to abide by these standards, and be available in a published form. Without published and approved standards, potential for misunderstanding and misinterpretation is significant. Standards are refered to for data formats, data transport, science data processing, and security. The choice of specific standards could be delayed until the ICD, however, the requirements in the IRD need to be specific enough to guide the developer in the choice of the standards. Further details are discussed in Appendix A.1.2.1.

4.3 ANALYSIS OF INTERFACE IMPLEMENTATION

Section 4.3.1 presents the results of the interface structure analysis, Section 4.3.2 the data content, completeness and expression results, and Section 4.3.3 the interface consistency results.

4.3.1 Interface Structure

The initial step was to determine the structure of the interface and to characterize this structure in an interface database. Block diagrams were drawn for each element and are represented in the documentation. Project approved sources, specifically the Architecture Description Document (ADD) and the Ground System Architecture Diagram (GSAD) were our source list of elements.

For the ECS<->TRMM IRD, a block diagram was drawn using these sources. Exhibit 4-2 shows the results of this analysis. Each element is represented by a box, with the interfaces shown by lines between the boxes. Both the ECS project documentation and the TRMM project documentation were reviewed to determine the structure of the interface as defined by the data items passed over the interface, and the functional and performance characteristics.

Section 4.2.1 presents the general issues found during the requirements analysis, including overall issues related to the documentation itself. Section 4.2.2 presents an overview of the results obtained from the technical integrity analysis, Section 4.2.3 the results obtained from the traceability analysis, and Section 4.2.4 a discussion on how the interface adheres to applicable standards. Detailed results for each of these sections can be found in Appendix A.

4.2.1 General

An apparent deficiency within the document is a lack of interface performance requirements. These performance requirements would normally be used to guide protocol selection and to steer the ICD development effort. Performance requirements should be in placed in the IRD to provide some basic design constraints. A number of design alternatives and system adaptations could then be considered during ICD development.

4.2.2 Technical Integrity

Several technical problems were identified during the requirements analysis phase of the ECS<->TRMM IRD. To be of high technical quality, requirements must be accurate, unambiguous, complete, consistent, and must allow design flexibility. All of the requirements in the ECS<->TRMM IRD were evaluated using these criteria. The problems that were discovered as a result of this analysis have been classified into general areas as follows: ambiguous requirements, incomplete requirements, inconsistent requirements, inaccurate requirements, and inflexible requirements. Ambiguous requirements are those requirements that are unclear and therefore allow for multiple interpretations. Inconsistent requirements either lack in agreement with the overall mission and/or desired functionality, or this agreement is questionable. Inaccurate requirements contain erroneous information that could impact the implementation. Incomplete requirements fail to clearly state the desired functionality, or in some cases a function has been inadvertently excluded. Inflexible requirements unduly constrain the design process by imposing the design solution outright.

The following breakdown reflects the overall results of the technical integrity analysis: eighteen (18) ambiguous requirements were found, ten (10) incomplete requirements were found, one (1) inconsistent requirement was found, no inaccurate or inflexible requirements were found. These numbers do not include the requirements having minor clarity or editorial problems, they include only those requirements needing substantive changes. Appendix A, Sections A.1.1.1 through A.1.1.4, present each of these problems, describing the specific requirements, a description of the problem with the requirement, and a recommendation as to how the requirement could be improved.

Number	Title	Description
1	Tracking of Standards	Sources and approach for use of standards is unclear. The document refers to standards frequently, maybe a section should be added to identify where the standards come from and how they will be regulated.
2	Non-Electronic Data Transfer	Are there any requirements for data to be sent via any other format than electronic transfer? Should the ability to ingest tape/disk be included? Identify other forms of data transfer, if applicable.
3	Electronic or Manual Processes	It is difficult to determine if these requirements will be met electronically or through human intervention. Distinguish between human and electronic interactions.
4	Occasional Special Quick-Look	How often will "occasional" quick look data be generated? Requirement should be more specific.
5	Missing diagram labels	Pg. 4-1, Figure 4-1: Two of the boxes aren't labeled. Provide labels
6	Puzzling footnote	Footnote states -Asterisks (*) flag requirements that support the interface between systems. I don't understand this. I thought all these requirements support the interface between systems! Clarify this footnote
7	Mushy requirement	Pg. 5-2, Requirement TRMM 1290: Who or what decides what the "appropriate" use of standards and COTS products is? Why define a requirement if its implementation is optional? (See also TRMM2280, TRMM3140, TRMM4140.) Delete this requirement
8	Science Team Support	This requirement does not directly involve the TRMM<->ECS interface. Delete this requirement.
9	TSDIS electronic schedule	It is unclear what type of electronic schedule will be provided from TSDIS. Is this a production schedule, spacecraft schedule, data transfer schedule? Clarify this item.
10	Ancillary Data Products	It would appear that several ancillary data products for TRMM are also of interest to ECS. However, since the ECS is not the prime source for these data, this discussion does not seem appropriate in the IRD. Delete this discussion.

Exhibit 4-1 RID Summary

4.2 ANALYSIS OF INTERFACE REQUIREMENTS

The ISVVP requirements analysis methodology was applied to the ECS<->TRMM IRD requirements. The 115 interface requirements within the IRD were analyzed in three principle areas - traceability, technical integrity, and testability. The technical integrity evaluation included an analysis of each requirement in terms of accuracy, completeness, ambiguity, consistency, and flexibility. The testability problems encountered were generally attributable to other technical integrity problems, although in some cases the requirements did not describe a testable function.

4. RESULTS

This section presents the results obtained from the pilot ECS<->TRMM IRD technical analysis. This analysis was begun on the June 1994 ECS<->TRMM IRD document and transitioned to the July 1994 version of the IRD. Several versions of the ECS <->TRMM IRD were released during this analysis, each containing different requirements. A general problem observed during the analysis of the interface requirements dealt with the baselining of project documents.

Section 4.1 presents a brief overview of the results obtained during the analysis. This section includes a summary of the Review Item Discrepancies (RIDs) submitted for the June 1994 version of the document and a description of the interface test methodology assignment. Section 4.2 presents the analysis of the interface requirements. Section 4.3 covers the analysis of the interface implementation and Section 4.4 discusses the interface development status. Detailed results obtained from the various analysis can be found in Appendix A.

In general, the ECS<->TRMM IRD provides a solid base for future ICD development. Problems were identified in each of the areas of analysis. Problems dealt with issues such as, internal document inconsistencies, as well as inconsistencies between the ECS<->TRMM IRD and the external documents. The problems identified can be corrected either in the baselined version of the IRD, or by the provision of the required detail in the ICDs. The most significant concern for this IRD deals with providing the appropriate level of detail necessary to guide the development effort. Throughout the IRD, requirements either are not specific enough or do not clearly state the intended functionality. While this practice allows for design flexibility, it also allows for multiple interpretations of the interface requirement. Given that there are different organizations developing each side of the interface, it is advantageous to resolve these clarity issues as soon as possible, since weaknesses not corrected in the IRD can easily be inherited by the ICDs.

4.1 INITIAL ANALYSIS

The initial analysis task performed on the ECS<->TRMM IRD was to complete an initial evaluation of the document and to submit RIDs. A total of 10 RIDs were submitted following the initial review of the June 1994, ECS<->TRMM IRD. These RIDs concerned general issues with the IRD and did not specifically address individual requirements. Exhibit 4-1 contains the specific information contained in these RIDs. One of these RIDs (#5) concerned a typographical mistake, the remaining nine RIDs were technical in nature. RIDs 1,6, and 9 address unclear or ambiguous requirements, RIDs 2, 3, and 4 flagged requirements missing pertinent information, and RIDs 7, 8, and 10 identified unnecessary requirements.

The experience gained during the pilot analysis of the TRMM<->ECS IRD highlighted the need for tools to support IRD and ICD analysis. The suggested tools include COTS tools, custom developed tools, or some combination of both. A separate activity, the IV&V Tools task, will evaluate and select these tools. Every effort will be made to ensure that analysis results can be directly imported into and exported out of these tools to minimize any duplication of effort.

During the pilot analysis, tracking interface specifications across multiple documents proved to be a challenging task. The need for a tool to support the capture, analysis and management of interface specifications across multiple sources (e.g., IRDs, ICDs, external requirements documents) was acknowledged early in the analysis. In response to this need, development of a data flow analysis tool was initiated by the IV&V tool team.

The tool developed, called Interface Analysis Database (IADB), facilitates the capture and analysis of potentially conflicting interface specifications derived from multiple sources. The tool utilizes a highly intuitive graphical user interface that allows the extraction of interface specifications from various documents, as well as the analysis of those specifications for consistency and completeness. The tool features an integrated data dictionary, capable of tracking alias, subclass, and subitem relationships between data classes, to aid in resolving apparent conflicts between interface specifications. The IADB tool will support future interface analysis efforts.

The second lesson learned during this analysis was that the documents used in the analysis need to be baselined. The IV&V team needs to become integrated with the GSFC review process by being added to distribution lists and by receiving schedule updates. We need to know when new versions of the documents we are reviewing are released and when comments are due to the authors. Working level points of contacts need to be developed to provide timely transmittal of significant issues.

Based on the TRMM pilot analysis we decided to shift towards doing interface analysis and reporting based on releases rather than on individual IRDs. This method seems to provide a more effective and efficient approach, since it reduces any overlaps in support and project capabilities, as well as, providing a forum to present any overall system level concerns which may arise from the system level analysis. With this method the main body of the reports will contain the overall system level concerns, and separate appendices will contain the interface specific concerns.

3. METHODOLOGY AND LESSONS LEARNED

The methodologies and approach used for the analysis of the IRD between ECS and the TRMM ground system are discussed in complete detail in the ISVVP. These methodologies are consistent with the EOS Certification Plan and the EOS IV&V Plan. A brief description of the analysis tasks that were performed is provided in Section 3.1; lessons learned from this analysis task are documented in Section 3.2. At each stage of the analysis, potential problems are identified, the impact that these problems may have on the interface are stated, and a corrective course of action is recommended.

3.1 METHODOLOGY

The interface requirements, data interfaces and data flows were analyzed in this pilot study. The analyses were performed manually and supplemented with a spreadsheet tool built in Excel. In the future, automated support tools supplied by the IV&V Tools group will be utilized.

The analysis of the TRMM<->ECS IRD interface requirements followed the approach described in Section 3.2 of the ISVVP. The interface requirements were analyzed in two areas: 1) technical integrity, and 2) testability. Technical integrity evaluation included an analysis of each requirement in terms of accuracy, completeness, ambiguity, consistency, and flexibility. Interface conflicts were identified, and each requirement was assessed for identification of a testable function and associated acceptance criteria.

The methodology used in the TRMM<->ECS interface implementation analysis was derived from Section 3.3 of the ISVVP. The main objectives of this analysis were to verify the content, completeness and consistency of the data flows described in the IRD. All data flows were examined to determine if each data flow is required, if all required data flows are present, and that all data flows are consistent with the functional and performance requirements for the interface. This analysis identified missing data items and inconsistencies between multiple source documents.

The methodology used to evaluate the TRMM schedule was to examine when the IRD was baselined by the ESDIS project, and to examine when the ICDs which are generated from the TRMM IRD are baselined. Several assumptions were made concerning the schedule information which was used. These assumptions are: there will be one ICD per interface, the ICD will contain a complete definition of the interface even if the interface is divided between multiple ECS releases, and that the dates for baselining the ICDs is the date for which all ICDs which are generated from the given IRD will be baselined.

3.2 LESSONS LEARNED

The MSFC DAAC is responsible for the higher level product generation, data archive and data distribution for LIS data products. Additional responsibilities include the archive and distribution of TMI, PR and GV data. The LaRC DAAC is responsible for the generation of CERES higher level data product, and the archival and distribution of these products. The GSFC DAAC performs the archival and distribution functions for the VIRS data products

2.5 REFERENCES

The following documents are referenced within this report:

1.	TRMM Ground Segment Specifications	TRMM 490-003	March 1993
2.	TRMM Mission Specification	TRMM 490-001	July 1993
3.	TRMM Science Requirements		August 30, 1993
4.	TSDIS Requirements Document	TSDIS-P200-V1	February 24, 1994
5.	Interface Requirements Document Between EOSDIS Core System (ECS) and the Tropical Rainfall Measuring Mission (TRMM) Ground System	194-219-SE1-018	June 1994
6.	Memorandum of Understanding Between the Tropical Rainfall Measuring Mission (TRMM) Project and the EOS Ground System and Operations Project (GSOP) for Science Data Archive and Distribution Support	NASA/GSFC 423-10-04	October 1991
7.	NASA Automated Information Security Handbook		
8.	Independent System Verification and Validation Plan (ISVVP)	Deliverable 0302	October 17, 1994
9.	EOSDIS Independent Verification and Validation Management Plan (IVVMP)	Deliverable 0301	August 15, 1994
10	Functional and Performance Requirements Specification for the Earth Observing System Data and Information System (EOSDIS) Core System	NASA/GSFC 423-41-02	June 2, 1994
11	EOSDIS Core System ECS) Preliminary Requirements Analysis Report	Deliverable 0502	October 28, 1994

outside the scope of this report. The evaluation of the Functional and Performance Requirements for the TRMM ground system will also be covered in the EOSDIS Core System ECS) Preliminary Requirements Analysis Report [Ref 11]. The types of analysis performed on this IRD where: interface analysis, requirements analysis, and schedule analysis.

2.4 BACKGROUND INFORMATION

The TRMM is a Mission to Planet Earth mission designed to advance the understanding of total rainfall and to determine the rate and total amount of rainfall occurring over the tropics and subtropics. TRMM will also carry two instruments designed to facilitate the measurement and analysis of the Earth's radiant energy budget and lightning and thunderstorm activity. The TRMM observatory is scheduled to be launched from Japan in August 1997 and will carry the following instruments:

- Visible Infrared Scanner (VIRS)
- TRMM Microwave Imager (TMI)
- Precipitation Radar (PR)
- Lightning Imaging Sensor (LIS)
- Clouds and Earth's Radiant Energy System (CERES)

The ECS provides a user interface to EOSDIS data and to information that is archived externally to EOSDIS and with which EOSDIS interfaces. ECS accepts user orders for EOS data, provides information about future data acquisitions and processing schedules, accepts and forwards data acquisition requests and processing requests, and provides access to the system management and status information.

Specifically for the TRMM mission, ECS provides a data archive for TRMM science data products, metadata, browse images, science algorithms, associated data and documentation. ECS also provides TRMM with non-TRMM data and TRMM science data for reprocessing. Access to TRMM data products for all EOSDIS users is possible through ECS on a 24-hour basis.

The Sensor Data Processing Facility (SDPF) is responsible for providing TRMM raw data storage, data quality accounting and, Level 0 and quick-look data processing and distribution. The Level 0 and quick-look data for VIRS, PR and TMI are sent from SDPF to TSDIS via Nascom for further processing. The CERES and LIS Level 0 and quick-look data are sent to the LaRC and MSFC DAACs, respectively for additional processing.

The TRMM Science Data and Information System (TSDIS) is home to the TRMM Science Data Operations Center (SDOC) and the Science Operations Control Center (SOCC). TSDIS is responsible for the generation of TRMM standard data products (Level 1A-3 PR, TMI, VIRS and GV). Once generated, these standard products are transferred to the MSFC DAAC to be archived.

2. INTRODUCTION

2.1 PURPOSE

The purpose of this report is to formally document the Independent Verification and Validation (IV&V) pilot analysis of the Draft IRD between the ECS and the TRMM Ground System (July 1994). The IRD was analyzed before baselining in an effort to refine our analysis approach and develop lessons for future key interface analysis activities.

This report describes the methods used for the TRMM pilot analysis and the automated tools that will be used in future analysis efforts. The report provides the results, conclusions, and recommendations obtained from the analysis.

2.2 OBJECTIVES OF THE PILOT ANALYSIS

The objective of this pilot analysis of the IRD between ECS and the TRMM ground system is to analyze the ECS<->TRMM interface requirements and interface implementations, and to refine our interface analysis methodologies.

The key interface analysis and subsequent testing will verify:

- Completeness, consistency, and correctness of the interfaces
- Functional and performance interface requirements are correctly and completely specified
- Correct implementation of protocols at all layers, with emphasis on error and exception handling, and correct formatting of all protocol data units
- Compatibility of data and applications at the application level
- Review of development schedules

The intent of key interface analysis is to identify potential problem areas early in the system life cycle, thereby reducing the level of effort and expense required to correct these problems, and to lay the ground work for key interface test planning. The problem areas that need correction are identified, projections are made as to the potential impact if the problem is not corrected, and a course of action is recommended to correct the problem.

2.3 SCOPE OF THE ANALYSIS

This report focuses on the analysis performed on the interfaces between the ECS and other elements supporting TRMM. These interfaces are identified as the TRMM Key Interface (Key Interface #7) on the Ground System Architecture Diagram and are documented in the ECS<->TRMM Interface Requirements Document. The IRD specifies a collection of interfaces between the ECS and elements external to ECS that support TRMM. Interfaces between the TRMM ground elements and systems other than ECS are

IRD and the TSDIS requirements document. The main overall comment concerning this IRD deals with providing the appropriate level of detail necessary to guide the development effort. Throughout the IRD, requirements either are not specific enough or do not clearly state the intended functionality. While this allows for design flexibility, it also allows for multiple interpretations of the interface requirement. Given that there are different organizations developing each side of the interface, it is advantageous to resolve these clarity issues as soon as possible. Weaknesses not corrected in the IRD can easily be inherited by the ICDs.

The analysis of the interface implementation examined the interface structure, data content, and completeness. During this analysis, two problem areas were observed. One issue pertains to the inconsistencies in data flow naming conventions, the other, to inconsistent interface performance requirements.

The IRD does not uniformly identify the data products being carried across system interfaces. These disparities were found both internal (comparing the descriptive data flows with the interface requirements) and external (comparing the IRD with other documentation) to the document. Examples include using the term “user notifications” versus “project status information”, or “ancillary and correlative data” versus the term “non-TRMM data”. The observed inconsistencies are not severe, but they should be addressed early on to avoid implementation and integration problems. The potential for such problems increases with the passage of time, staff turnover, etc. It is recommended that the ESDIS project establish and baseline a detailed set of data definition, element names. All interface documentation (IRDs and ICDs) should adhere to these baselined definitions. Such project documents as the Ground System Architecture Diagram (GSAD) and Architecture Description Document (ADD) could, if updated, contain these data definitions.

The TRMM Technical Analysis Report (TAR) adopted a number of conventions which should be considered for use in the other IRDs. Data flows were numbered and cross referenced to a data description table, which included descriptions of data types, interface functions, and Interface Control Document (ICD) responsibility. Such clear linkage and descriptions expedite the analysis process and should be considered project wide.

Second, the analysis of interface implementation identified inconsistencies in performance requirements (Examples were found where the IRD and external document were consistent, but both documents were inconsistent with the ECS F&PR). The impact of this inconsistency is that an interface could pass the system test and fail the key interface test or conversely, pass the key interface test and fail the system test. Assuming the interface documentation is correct, it is recommended that the ECS F&PR be updated.

The pilot analysis served to refine our interface analysis approach. Two lessons learned were gained from this pilot analysis, the first lesson learned was fed directly into IV&V tool development activities. An interface analysis database tool was developed that facilitates the analysis of interface specifications for consistency and completeness. This tool will be used to support future IRD analysis efforts. The second lesson learned was that the IV&V team needs to become more integrated with the GSFC review process by being added to distribution lists and by receiving schedule updates.

In general, the ECS<->TRMM IRD provides a solid base for future ICD development. Problems were identified in each of the areas of analysis. The problems identified can be corrected either in the baselined version of the IRD, or by the provision of the required detail in the ICDs. The majority of the minor problems dealt with internal document inconsistencies while the others dealt with inconsistencies between the ECS<->TRMM

1. EXECUTIVE SUMMARY

The purpose of this report is to formally document the Independent Verification and Validation (IV&V) pilot analysis of the July 1994 Version of the Interface Requirements Document (IRD) between the EOSDIS Core System (ECS) and the Tropical Rainfall Measuring Mission (TRMM) ground system. The pilot analysis was performed prior to baselining of the TRMM IRD and served to both identify specific TRMM interface issues and to refine our analysis methodology. Results of future interface requirements analyses will be informally conveyed to the ESDIS project, and formally documented for each release instead of for each IRD.

Two analyses were performed on the TRMM IRD and referenced interface documentation. First, a requirements analysis was conducted to evaluate the technical integrity of the requirements, as described in Section 3.2.1 of the Independent System Verification and Validation Plan (ISVVP). Second, an analysis of the interface implementation was performed following the methods prescribed in Section 3.3.1 of the ISVVP. This report describes the analysis methods used and how these methods where applied to the IRD, as well as the results, conclusions, and recommendations obtained from the analysis. In addition to these two analysis a schedule evaluation was performed to alert the IV&V team of any schedule conflicts or schedule concerns.

The technical integrity review covers three (3) principle areas: traceability, quality and testability. Verification of requirements traceability was not performed since the Hughes Applied Information Systems, Inc. (HAIS) traceability database was not populated with IRD information in time to perform traceability analysis. Traceability analysis of the interface requirements will be performed on the baselined version of the IRD.

The technical integrity review identified problems resulting from the incomplete, inconsistent or ambiguous specification of requirements. The majority of the issues identified were clarity problems and could be mitigated by using more precise terminology. Some of the problems, however, pertained to the incomplete specification of a function or data flow and may require a greater level of effort to correct.

The ambiguity problems encountered were typically related to the use of imprecise terminology (e.g., “support”, “archive”) or by the inadequate specification of a method of interaction (e.g., “electronic vs. human” or “automatic vs. manual”). Completeness problems were found where the level of detail was not sufficient to assist the design process (e.g., lack of performance requirements, scheduling functions not adequately specified). The inconsistencies observed were misplaced requirements (i.e., the requirement did not belong in this IRD) or requirements that were not uniformly applied to the ECS or TRMM elements. The specific issues are documented in Appendix A.

List of Exhibits

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TRMM Technical Analysis Report
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Tropical Rainfall Measuring Mission (TRMM)
Technical Analysis Report
Draft
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